



## Switched Band-Pass Filters for Adaptive Transceivers

**Switched filters could be reconfigured to conform to diverse standards.**

*Stennis Space Center, Mississippi*

Switched band-pass filters are key components of proposed adaptive, software-defined radio transceivers that would be parts of envisioned digital-data-communication networks that would enable real-time acquisition and monitoring of data from geographically distributed sensors. Examples of sensors to be connected to such networks include security cameras, radio-frequency identification units, and geolocation units based on the Global Positioning System. Through suitable software configuration and without changing hardware, these transceivers could be made to operate according to any of a number of complex wireless-communication standards that could be characterized by diverse modulation schemes, bandwidths, and data-handling protocols.

The adaptive transceivers would include field-programmable gate arrays

(FPGAs) and digital signal-processing hardware. In the receiving path of a transceiver, the incoming signal would be amplified by a low-noise amplifier (LNA). The output spectrum of the LNA would be processed by a band-pass filter operating in the frequency range between 900 MHz and 2.4 GHz. Then a down-converter would translate the signal to a lower frequency range to facilitate analog-to-digital conversion, which would be followed by baseband processing by one or more FPGAs. In the transmitting path, a digital stream would first be converted to an analog signal, which would then be up-converted to a selected frequency band before being applied to a transmitting power amplifier.

The aforementioned band-pass filter in the receiving path would be a combination of resonant inductor-and-capacitor filters and switched band-pass filters. The

overall combination would implement a switch function designed mathematically to exhibit desired frequency responses and to switch the signal in each frequency band to an analog-to-digital converter appropriate for that band to produce a digital intermediate-frequency signal for digital signal processing.

*This work was done by Ray Wang of Mobitrum Corp. for Stennis Space Center.*

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*Mobitrum Corporation*

*8070 Georgia Avenue, Suite 209*

*Silver Spring, MD 20910*

*Telephone No.: (301) 585-4040*

*E-mail: ray\_wang@mobitrum.com*

*Refer to SSC-00260, volume and number of this NASA Tech Briefs issue, and the page number.*

## Noncoherent DTTLs for Symbol Synchronization

**At high signal-to-noise ratios, performances would approach those of coherent DTTLs.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Noncoherent data-transition tracking loops (DTTLs) have been proposed for use as symbol synchronizers in digital communication receivers. [Communication-receiver subsystems that can perform their assigned functions in the absence of synchronization with the phases of their carrier signals ("carrier synchronization") are denoted by the term "noncoherent," while receiver subsystems that cannot function without carrier synchronization are said to be "coherent."] The proposal applies, more specifically, to receivers of binary phase-shift-keying (BPSK) signals generated by directly phase-modulating binary non-return-to-zero (NRZ) data streams onto carrier signals having known frequencies but unknown phases. The proposed noncoherent DTTLs would be modified versions of traditional DTTLs, which are coherent.

The symbol-synchronization problem is essentially the problem of recovering symbol timing from a received signal. In the traditional, coherent approach to symbol synchronization, it is necessary to establish carrier synchronization in order to recover symbol timing. A traditional DTTL effects an iterative process in which it first generates an estimate of the carrier phase in the absence of symbol-synchronization information, then uses the carrier-phase estimate to obtain an estimate of the symbol-synchronization information, then feeds the symbol-synchronization estimate back to the carrier-phase-estimation subprocess. In a noncoherent symbol-synchronization process, there is no need for carrier synchronization and, hence, no need for iteration between carrier-synchronization and symbol-synchronization subprocesses.

The proposed noncoherent symbol-synchronization process is justified theoretically by a mathematical derivation that starts from a maximum *a posteriori* (MAP) method of estimation of symbol timing utilized in traditional, coherent DTTLs. In that MAP method, one chooses the value of a variable of interest (in this case, the offset in the estimated symbol timing) that causes a likelihood function of symbol estimates over some number of symbol periods to assume a maximum value. In terms that are necessarily oversimplified to fit within the space available for this article, it can be said that the mathematical derivation involves a modified interpretation of the likelihood function that lends itself to noncoherent DTTLs.

The proposal encompasses both linear and nonlinear noncoherent DTTLs. The performances of both have

been computationally simulated; for comparison, the performances of linear and nonlinear coherent DTTLs have also been computationally simulated. The results of these simulations show that, among other things, the expected mean-square timing errors of coherent

and noncoherent DTTLs are relatively insensitive to window width. The results also show that at high signal-to-noise ratios (SNRs), the performances of the noncoherent DTTLs approach those of their coherent counterparts at, while at low SNRs, the noncoherent DTTLs

incur penalties of the order of 1.5 to 2 dB.

*This work was done by Marvin Simon and Andre Tkachenko of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-42540*

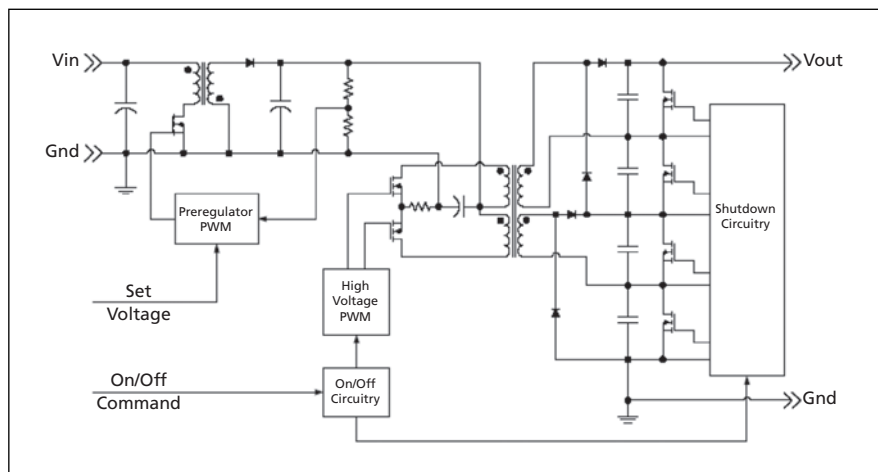
## High-Voltage Power Supply With Fast Rise and Fall Times

**Output is electronically programmable and electronically switchable.**

*Marshall Space Flight Center, Alabama*

A special-purpose high-voltage power supply can be electronically switched on and off with fast rise and fall times, respectively. The output potential is programmable from 20 to 1,250 V. An output current of 50  $\mu$ A can be sustained at 1,250 V. The power supply was designed specifically for electronically shuttering a microchannel plate in an x-ray detector that must operate with exposure times as short as 1 ms. The basic design of the power supply is also adaptable to other applications in which there are requirements for rapid slewing of high voltages.

The power-supply circuitry (see figure) includes a preregulator, which is used to program the output at 1/30 of the desired output potential. After the desired voltage has been set, the outputs of a pulse width modulator (PWM) are enabled and used to amplify the preregulator output potential by 30. The amplification is achieved by use of two voltage doublers with a transformer that has two primary and two secondary windings. A resistor is used to limit the current by controlling the drive voltage of two field-effect transistors (FETs) during turn-on of the PWM. A pulse transformer is



This Power-Supply Circuit features a rise time of 80  $\mu$ s and a fall time of 60  $\mu$ s.

used to turn on four FETs to short-circuit four output capacitors when the outputs of the PWM have been disabled. The most notable aspects of the performance of the power supply are a rise time of only 80  $\mu$ s and a fall time of only 60  $\mu$ s at a load current of 50  $\mu$ A or less. Another notable aspect is that the application of a 0-to-5-V square wave to a shutdown pin of the PWM

causes the production of a 0-to-1,250-V square wave at the output terminals.

*This work was done by Douglas B. Bear-den, Richard M. Acker, and Robert E. Kapustka of Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at [sammy.a.nabors@nasa.gov](mailto:sammy.a.nabors@nasa.gov). Refer to MFS-31912-1.*

## Waveguide Calibrator for Multi-Element Probe Calibration

**Acoustic waveguide technology produces the same acoustic field at each of the sensing elements.**

*Stennis Space Center, Mississippi*

A calibrator, referred to as the "spider" design, can be used to calibrate probes incorporating multiple acoustic sensing elements. The application is an acoustic energy density probe, although the calibrator can be used for other types of acoustic probes. The calibrator relies on the use of acoustic waveguide technology to produce the same acoustic field at each of the sensing elements. As a result, the sensing elements

can be separated from each other, but still calibrated through use of the acoustic waveguides.

Standard calibration techniques involve placement of an individual microphone into a small cavity with a known, uniform pressure to perform the calibration. If a cavity is manufactured with sufficient size to insert the energy density probe, it has been found that a uniform pressure field can only be created at very

low frequencies, due to the size of the probe. The size of the energy density probe prevents one from having the same pressure at each microphone in a cavity, due to the wave effects.

The "spider" design probe is effective in calibrating multiple microphones separated from each other. The spider design ensures that the same wave effects exist for each microphone, each with an individual sound path. The cali-